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Applicant's or agent's file reference
1085-015WO01

International application No.
(if known)

International filing date (day/month/year)
(if known)

(Earliest) Priority date
(day/month/year)
22 October 2004

Applicant
NISSAN MOTOR CO., LTD. et al.

Title of invention
BATTERY MODULE AND BATTERY ASSEMBLY

The applicant hereby requests the International Bureau to acknowledge to the following person (include full name, address, facsimile No. and telephone No.):

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the receipt by the following means:

☐ mail (surface, air mail, registered) ☐ delivery service ☒ facsimile transmission ☐ hand delivery

of the documents/elements listed below:

- ☒ PCT request (including declaration sheets) (4 pages)
- ☒ description (excluding sequence listing and/or tables relating thereto) (13 pages)
- ☒ claims (5 pages)
- ☒ abstract (1 pages)
- ☒ drawings (12 pages)
- ☐ sequence listing and/or tables relating thereto (pages)
- ☒ fee calculation sheet
- ☐ separate authorization to charge deposit account
- ☒ cheque (indicate currency and amount) **\$3118.00 / U.S. Dollars**
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- ☐ power of attorney (general power, copy of general power, separate power) (indicate kind and number)
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- ☐ statement accompanying sequence listing and/or tables relating thereto in electronic form (if more than one, indicate number)
- ☐ accompanying letter
- ☐ other (specify):

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REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

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International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) 1085-015WO01

Box No. I TITLE OF INVENTION

BATTERY MODULE AND BATTERY ASSEMBLY

Box No. II APPLICANT

☐ This person is also inventor

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

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Applicant's registration No. with the Office

State (that is, country) of nationality:
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State (that is, country) of residence:
Japan

This person is applicant
for the purposes of:

☐ all designated
States

☒ all designated States except
the United States of America

☐ the United States
of America only

☐ the States indicated in
the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

NISSAN NORTH AMERICA
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This person is:

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☐ applicant and inventor

☐ inventor only (If this check-box is
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Applicant's registration No. with the Office

State (that is, country) of nationality:
Japan

State (that is, country) of residence:
Japan

This person is applicant
for the purposes of:

☐ all designated
States

☒ all designated States except
the United States of America

☐ the United States
of America only

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☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒ agent

☐ common
representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

SIEFFERT, Kent J.
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☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)*If none of the following sub-boxes is used, this sheet should not be included in the request.*

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HASHIDA Osamu
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This person is:

- ☐ applicant only
☒ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

Japan

State (that is, country) of residence:

Japan

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☒ the United States of America only☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☐ the United States of America only☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

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Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☐ the United States of America only☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

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Box No. V DESIGNATIONS

The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.

However,

- ☐ DE Germany is not designated for any kind of national protection
- ☐ KR Republic of Korea is not designated for any kind of national protection
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(The check-boxes above may be used to exclude (irrevocably) the designations concerned in order to avoid the ceasing of the effect, under the national law, of an earlier national application from which priority is claimed. See the Notes to Box No. V as to the consequences of such national law provisions in these and certain other States.)

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item (1) 17 October 2005 (17.10.2005)	2005-301177	JP		
item (2) 22 October 2004 (22.10.2004)	2004-308346	JP		
item (3)				

- ☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office) identified above as:

- ☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ other, see Supplemental Box

* Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)).

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA / .EP.....

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year) Number Country (or regional Office)

Box No. VIII DECLARATIONS

The following declarations are contained in Boxes Nos. VIII (i) to (v) (mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):

		Number of declarations
<input type="checkbox"/> Box No. VIII (i)	Declaration as to the identity of the inventor	:
<input type="checkbox"/> Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	:
<input type="checkbox"/> Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	:
<input type="checkbox"/> Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)	:
<input type="checkbox"/> Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	:

Box No. IX CHECK LIST; LANGUAGE OF FILING		
<p>This international application contains:</p> <p>(a) on paper, the following number of sheets:</p> <p style="margin-left: 20px;">request (including declaration sheets) : 4</p> <p style="margin-left: 20px;">description (excluding sequence listing and/or tables related thereto) : 13</p> <p style="margin-left: 20px;">claims : 5</p> <p style="margin-left: 20px;">abstract : 1</p> <p style="margin-left: 20px;">drawings : 12</p> <p style="margin-left: 20px;">Sub-total number of sheets : 35</p> <p style="margin-left: 20px;">sequence listing : </p> <p style="margin-left: 20px;">tables related thereto : </p> <p style="margin-left: 20px;"><i>(for both, actual number of sheets if filed on paper, whether or not also filed in electronic form; see (c) below)</i></p> <p style="margin-left: 20px;">Total number of sheets : 35</p> <p>(b) <input type="checkbox"/> only in electronic form (Section 801(a)(i))</p> <p style="margin-left: 20px;">(i) <input type="checkbox"/> sequence listing</p> <p style="margin-left: 20px;">(ii) <input type="checkbox"/> tables related thereto</p> <p>(c) <input type="checkbox"/> also in electronic form (Section 801(a)(ii))</p> <p style="margin-left: 20px;">(i) <input type="checkbox"/> sequence listing</p> <p style="margin-left: 20px;">(ii) <input type="checkbox"/> tables related thereto</p> <p>Type and number of carriers (diskette, CD-ROM, CD-R or other) on which are contained the</p> <p style="margin-left: 20px;"><input type="checkbox"/> sequence listing:</p> <p style="margin-left: 20px;"><input type="checkbox"/> tables related thereto:</p> <p style="margin-left: 20px;"><i>(additional copies to be indicated under items 9(ii) and/or 10(ii), in right column)</i></p>	<p>This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item):</p> <p>1. <input checked="" type="checkbox"/> fee calculation sheet : 1</p> <p>2. <input type="checkbox"/> original separate power of attorney : </p> <p>3. <input type="checkbox"/> original general power of attorney : </p> <p>4. <input type="checkbox"/> copy of general power of attorney; reference number, if any: : </p> <p>5. <input type="checkbox"/> statement explaining lack of signature : </p> <p>6. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): : </p> <p>7. <input type="checkbox"/> translation of international application into (language): : </p> <p>8. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material : </p> <p>9. <input type="checkbox"/> sequence listing in electronic form (indicate type and number of carriers)</p> <p style="margin-left: 20px;">(i) <input type="checkbox"/> copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application) : </p> <p style="margin-left: 20px;">(ii) <input type="checkbox"/> (only where check-box (b)(i) or (c)(i) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter : </p> <p style="margin-left: 20px;">(iii) <input type="checkbox"/> together with relevant statement as to the identity of the copy or copies with the sequence listing mentioned in left column : </p> <p>10. <input type="checkbox"/> tables in electronic form related to sequence listing (indicate type and number of carriers)</p> <p style="margin-left: 20px;">(i) <input type="checkbox"/> copy submitted for the purposes of international search under Section 802(b-quater) only (and not as part of the international application) : </p> <p style="margin-left: 20px;">(ii) <input type="checkbox"/> (only where check-box (b)(ii) or (c)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Section 802(b-quater) : </p> <p style="margin-left: 20px;">(iii) <input type="checkbox"/> together with relevant statement as to the identity of the copy or copies with the tables mentioned in left column : </p> <p>11. <input checked="" type="checkbox"/> other (specify): PCT/RO/198 (RO/IB) : 1</p>	<p>Number of items</p>
<p>Figure of the drawings which should accompany the abstract: 4</p>	<p>Language of filing of the international application: English</p>	
<p>Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE</p> <p><i>Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).</i></p> <div style="border: 1px solid black; height: 40px; margin-bottom: 5px;"></div> <p>H. Sanders Gwin, Jr. Agent for Applicant</p>		

For receiving Office use only	
<p>1. Date of actual receipt of the purported international application:</p>	<p>2. Drawings:</p> <p><input type="checkbox"/> received:</p> <p><input type="checkbox"/> not received:</p>
<p>3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:</p>	
<p>4. Date of timely receipt of the required corrections under PCT Article 11(2):</p>	
<p>5. International Searching Authority (if two or more are competent): ISA /</p>	
<p>6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid</p>	
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This sheet is not part of and does not count as a sheet of the international application.

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FEE CALCULATION SHEET

Annex to the Request

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International Application No.

Date stamp of the receiving Office

Applicant's or agent's
file reference

1085-015WO01

Applicant

NISSAN MOTOR CO., LTD.

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE 79.00 T

2. SEARCH FEE 1877.00 S

International search to be carried out by EP
(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FILING FEE

Where items (b) and/or (c) of Box No. IX apply, enter Sub-total number of sheets } 35
Where items (b) and (c) of Box No. IX do not apply, enter Total number of sheets }

i1 first 30 sheets 1102.00 i1

i2 5 x 12 = 60.00 i2
number of sheets fee per sheet
in excess of 30

i3 additional component (only if a sequence listing and/or tables
related thereto are filed in electronic form under Section 801(a)(i),
or both in that form and on paper, under Section 801(a)(ii)):

400 x = i3
fee per sheet

Add amounts entered at i1, i2 and i3 and enter total at I 1162.00 I

(Applicants from certain States are entitled to a reduction of 75% of the international filing fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the international filing fee.)

4. FEE FOR PRIORITY DOCUMENT (if applicable) P

5. TOTAL FEES PAYABLE 3118.00

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

TOTAL

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BATTERY MODULE AND BATTERY ASSEMBLY**TECHNICAL FIELD**

[0001] The invention pertains to a battery module and to a battery assembly, which is constructed with the aforementioned battery modules.

BACKGROUND

[0002] Multiple cells are electrically connected in series and/or in parallel to produce a battery assembly having high output and high capacity. In order to accommodate ease of production, in general, a battery assembly utilizes battery modules where many cells are stored inside a case and used as a module within the battery assembly. In the battery module, multiple cells are connected electrically inside the case and negative and positive output terminals are provided to the outside from the case. Furthermore, based on the output and capacity required, a suitable number of battery modules are connected electrically in series and/or in parallel to produce a battery assembly. Therefore, in an assembly system where individual battery modules are assembled while fastening with screws, a complicated fastening operation is frequently required and may be inconvenient.

SUMMARY

[0003] In general, the invention provides a battery module that makes it possible to provide a less complicated battery assembly and to produce a battery assembly that comprises the aforementioned battery modules. Furthermore, in order to simplify construction of the battery assembly, simplification of construction of the battery module itself is an aspect of the invention.

[0004] In one embodiment, a battery module, which forms an item unit for construction of a battery assembly, comprises a cell unit having a plurality of cells, and a housing and a cover to store the cell unit. The battery module further comprises a shaft member inserted into a through-hole provided in the cell unit and a through-hole provided in the housing and a through-hole provided in the cover, wherein the shaft member comprises a length that allows protrusion from each of the housing and the cover.

[0005] In another embodiment, a battery assembly comprises a plurality of battery modules wherein an axis of a first shaft member of a first battery module and an axis of a second shaft member of a second battery module are matched at the time of connecting the second shaft member along the axis direction as the first shaft member is fitted at an interfitting member of the second shaft member. The plurality of battery modules are stacked where each battery module's interfitting member of a shaft member are locked, and a support structure that supports the battery modules from both sides of the plurality of battery modules when each of the battery module's interfitting members are locked.

[0006] In another embodiment, a method of manufacturing a battery module comprises storing a cell unit, which contains a plurality of battery cells, within a housing having a cover to form a storage space and inserting a shaft member into a through-hole provided in the cell unit and a through-hole provided in the cover and a through-hole provided in the housing. The shaft member comprises a length that allows protrusion from each of the cover and the housing. The method further comprises fastening a fastening member to the cover at an area where the shaft member protrudes from the cover, locking a locking member to the housing at an area where the shaft member protrudes from the housing, such that the lock member is free to move between a first position where insertion into the through-hole of the cell unit and the through-holes of each of the cover and housing is allowed and a second position where separation of the cell units and each of the cover and housing from the shaft member is prevented, and inserting the cover, the cell unit, and the housing in said order onto the shaft member from the lock member side toward the fastening member, wherein the shaft member doubles as a jig.

[0007] In another embodiment, a method of manufacturing a battery assembly comprises matching an axis of a first shaft member of a first battery module and an axis of a second shaft member of a second battery module at the time of connecting the second shaft member along the axis direction as the first shaft member is fitted at an interfitting member of the second shaft member. The method further comprises stacking a plurality of battery modules where each battery module's interfitting member of the shaft member are locked, and inserting the plurality of battery modules into a support structure that supports the battery modules from both sides of the plurality of battery modules when each of the battery module's interfitting members are locked.

[0008] In another embodiment, a battery module, which forms an item unit for construction of a battery assembly, comprises means for enclosing a plurality of cells, a shaft member inserted into a through-hole provided in a cell unit and a through-hole provided in the enclosing means, wherein the shaft member comprises a length that allows protrusion from the enclosing means. The battery module further comprises means for locking the shaft member to the housing or to the cover.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is a perspective view of a schematic structure of a battery assembly of an embodiment of the present invention.

[0010] FIG. 2 is a schematic cross-section view at line 2-2 of FIG. 1.

[0011] FIG. 3 is a perspective view of an example of battery module.

[0012] FIG. 4 is a cross-section view at line 4-4 of FIG. 3 and shows the main unit of the group of battery modules comprising a multilayer stack of battery modules.

[0013] FIG. 5 is a perspective view of an exploded view of upside-down battery module shown in FIG. 3.

[0014] FIG. 6 is a perspective view of an exemplary flat cell.

[0015] FIG. 7 is perspective view of the shaft member included in the battery module.

[0016] FIG. 8(A) and FIG. 8(B) are a vertical cross-section view and top view of shaft member.

[0017] FIG. 9(A) and FIG. 9(B) are cross-section views of the main unit of the shaft member.

[0018] FIG. 10 is a perspective view of the shaft member used as a jig at the time of assembly of the battery module.

[0019] FIG. 11(A) and 11(B) are a vertical cross-section view and a top view of a battery module used for an explanation of a modified example of a shaft member.

[0020] FIG. 12 is a cross-section view of the main area of battery module of a comparison example where the sleeve alone is inserted into the through-hole of the cell unit.

[0021] FIG. 13 is a cross-section view of the main area of a battery assembly of a comparison example constructed with the battery module shown in FIG. 12.

DETAILED DESCRIPTION

[0022] As shown in FIG. 1 and FIG. 2, battery assembly 11 is constructed with each of battery modules 20 as an individual unit, which are arranged as groups of battery modules 25. Multiple of battery modules 20 are stacked with space 60 and support means 50 that support the group of battery modules 25. When a given number of battery modules 20 are connected in series and/or in parallel, battery assembly 11 providing the desired current, voltage and capacity is formed. An exemplary embodiment of battery assembly 11 (also referred to as an "assembled battery") includes twelve battery modules 20. In FIG. 1, twelve battery modules 20 are arranged horizontally in four rows of three stacked vertically.

[0023] In one embodiment, battery module 20 is an air-cooled type and the gaps 60 between battery modules 20 are used as cooling air passages 61 for cool air to flow down for cooling each battery module 20. Cool air flowing into each battery module 20 is cooled to reduce the battery temperature and to prevent deterioration of the properties such as charging efficiency. Though it is not shown in FIG. 1 and FIG. 2, an appropriate connection member, such as a bus bar, is used for connection of battery modules 20 in series or in parallel. Battery assembly 11 may be installed in automobiles, trains or other vehicles. Support member 50 and assembly of battery assembly 11 are explained in detail below.

[0024] It should be noted that a battery module is a type of assembled battery from the standpoint of having multiple cells connected electrically but in the present specification, a battery module is used as a component for assembly of a "battery assembly" (such as battery assembly 11). A "battery module" (such as battery module 20) refers to multiple cells contained inside a case.

[0025] Battery module 20 is explained briefly using FIG. 3-FIG. 10 as references. Battery module 20 has a cell unit 40 containing many flat cells 30, housing 22, and cover 23. Housing 22 and cover 23 form a module case 21 for holding cell units 40. Cell unit 40 contains through-holes 45. Housing 22 and cover 23 contain through-holes 24. Battery module 20 also contains a shaft member 70 that is inserted into through-holes 24 and through holes 45 and has a length that extends beyond each of the housing 22 and cover 23. For the portion where shaft member 70 protrudes from cover 23, a fastening member 71 is locked to cover 23. For the portion where shaft member 70 protrudes from housing 22, a lock member 72 is locked to housing 22. Lock member 72 is constructed

so that it is free to move between first position P1 (FIG. 9) where insertion to the through-hole 45 of the cell unit 40 and to the through-hole 24 of each of housing 22 and cover 23 is allowed and a second position P2 (FIG. 9) where separation of the cell unit 40 and housing 22 and cover 23 from the shaft member is prevented. Shaft member 70 doubles as a jig for insertion of cover 23, cell unit 40, and housing 22 in said order from lock member 72 in the direction of fastening member 71 at the time of assembly of battery module 20 (See FIG. 10). The invention is explained in further detail below.

[0026] In FIG. 3-FIG. 5, module case 21 used for storage of cell unit 40 comprises box-shaped housing 22 provided with opening 22a (FIG. 5) and cover 23 that forms a lid for opening 22a. Cover 23 and housing 22 are mutually locked as an edge member of one of the cases is rolled in over an edge member of the other case. In other words, edge member 23a of cover 23 is rolled in over the edge member 22c on the wall 22b of housing 22 by a self-locking process (see FIG. 4 for reference).

[0027] Housing 22 and cover 23 may be made of a relatively thin sheet steel or sheet aluminum and are a pre-determined shape that may be provided by press molding. Inside module case 21, cell unit 40 comprises multiple flat cells 30 (eight cells shown in the FIG. 5) that are connected in series. Cell unit 40 also includes insulating spacer 41 used for retention of electrode tabs 31 and 32 of flat cell 30 and positive and negative electrode terminals 42 and 43. Positive and negative electrode terminals 42 and 43 are fed through to the outside from module case 21 through notch members 22d and 22e provided in an area of wall 22b of housing 22.

[0028] In FIG. 5, item 44 indicates the entry for a connector (not shown in the FIG. 5) connected to a voltage detection terminal (not shown in the FIG. 5) of each flat cell 30. Entry 44 is exposed to the outside through notch member 22f of the module case 21 provided in a portion of wall 22b, as well. For insertion of shaft member 70, through-holes 24 are provided at the four corners of housing 22 and through-holes 45 are provided at two locations of each insulation spacer 41.

[0029] In FIG. 6, flat cell 30 is, for example, a lithium ion secondary battery, and a laminated power element (not shown in FIG. 6) where a positive plate, negative plate and separator are laminated in said order and shielded with a sheath material 33. One end of flat cells 30 is electrically connected with the power element and sheet-like electrode tabs 31 and 32 lead out from sheath material 33. Electrode tabs 31 and 32 extend to both sides in the longitudinal direction (horizontally in FIG. 6) of flat cell 30. In a flat cell 30 having a laminated type power element, it is necessary to apply pressure to the power

element to compress the power element in order to maintain the distance between electrodes and to maintain battery performance. Therefore, each flat cell 30 is stored inside module case 21 in a manner that compresses the power element.

[0030] In FIG. 4 and FIG. 7 - FIG. 9, the shaft member 70 of the aforementioned embodiment has locator 80 formed by center hole 80a and sleeve 90 formed by center hole 90a and the aforementioned two are connected. Shaft member 70 has a hollow structure formed by center hole 70a (generic name for center holes 80a and 90a).

[0031] Locator 80 and sleeve 90 have an outer diameter smaller than the inner diameter of through-hole 45 of cell unit 40 and through-hole 24 of cover 23 and housing 22, and shaft member 70 can be inserted into through-holes 24 and 45. The length of each locator 80 and sleeve 90 is set in such a manner that the locator 80 protrudes from the housing 22 and the sleeve 90 protrudes from the cover 23 in the assembled state of the battery module 20. The material used for the locator 80 and sleeve 90 is not especially limited and in the example shown in the figure, locator 80 is made of a resin material and sleeve 90 is made of a metal material. As shown in an enlarged view of FIG. 9(A), an opening is provided for receiving the base end of locator 80 at center hole 90a of sleeve 90. On the inner surface of the opening, a vertical channel 91 extends along the axis direction of the shaft member 70, from the upper edge downward (FIG. 9A), and a circular channel 92 extends in the peripheral direction. Circular channel 92 is formed at an angle of 90 degrees, for example. Meanwhile, a projection 81 having a size to be fitted to vertical channel 91 and circular channel 92 is formed at the base end of the outer surface of locator 80. The key structure comprises vertical channel 91, circular channel 92, and projection 81. Furthermore, when locator 80 is inserted into sleeve 90, projection 81 follows vertical channel 91 and when locator 80 is rotated 90 degrees, for example, projection 81 follows circular channel 92, thus, the connection state of locator 80 and sleeve 90 can be set.

[0032] Fastening member 71 is located at the position where shaft member 70 protrudes from cover 23, that is, sleeve 90. An exemplary embodiment of fastening member 71 is shown in the FIGS. 4 and 7 as having a flange shape having a greater outer diameter than the inner diameter of through-holes 24 and 45. When the upper surface of fastening member 71 comes in contact with the lower surface of cover 23, fastening member 71 is locked to cover (FIG. 4).

[0033] Lock member 72 is located on the portion of the shaft member 70 that protrudes from housing 22, that is, locator 80. An exemplary embodiment of lock member 72, shown in the FIGS. 4, 7-9, has a claw-shape or umbrella-shape that opens with a descending slope from the outer surface of locator 80 toward the outer direction of the diameter and fastening member 71. When the end member of lock member 72 comes in contact with the upper surface of housing 22, lock member 72 is locked to the housing 22 (see FIG. 4 and FIG. 9A). As shown in FIGS. 9A-9B, claw-shaped lock member 72 has a structure that is free to move between the first position P1 where insertion into through-hole 45 of cell unit 40 and into through-hole 24 of housing 22 and cover 23 is allowed and a second position P2 where separation of cell unit 40, housing 22, and cover 23 from shaft member 70 is prevented.

[0034] In the exemplary embodiment, lock member 72 has a claw shape made of a resin material and is elastic. Furthermore, lock member 72 opens with a descending slope in the radial direction and engages fastening member 71. Therefore, when cover 23, cell unit 40, or housing 22 is inserted onto shaft member 70 from lock member 72 toward the direction of fastening member 71, the end member of the lock member 72 is pressed toward the inner side of the outer surface of locator 80 or toward the direction of the axis of the shaft member 70 as it is being guided by the inner surface of the through-holes 24 and 45, and reaches the first position P1 (FIG. 9B). Furthermore, when through-holes 24 and 45 pass through the lock member 72, lock member 72 opens based on its elasticity and is restored to the second position P2 (FIG. 9A). In other words, in this exemplary embodiment, lock member 72 is free to move between first position P1 and the second position P2 as the lock member undergoes elastic distortion toward the axis of shaft member 70.

[0035] As shown in FIG. 9A and FIG. 9B, accordion channel 73 may be provided near the base end of lock member 72 in order to achieve smooth movement of lock member 72. Furthermore, in order to ensure return of lock member 72 to second position P2, an elastic component such as a flat spring, spring, or rubber may be provided between the outer surface of locator 80 and lock member 72 and an elastic force may be applied for moving lock member 72 toward the second position P2.

[0036] As shown in FIG. 4 and FIG. 8, interfitting members are provided at both end faces of shaft member 70 in the axis direction so that the axis of shaft member 70 and the axis of another shaft member 70 can be matched at the time of connecting the shaft members with the end faces mutually fitted together. In specific terms, a projection 82 is

formed on the end face of locator 80 of shaft member 70 and a recessed member 93, having a shape corresponding to projection 82, is formed on the end face of sleeve 90. And interfitting member comprises projection 82 and recessed member 93.

[0037] FIG. 10 illustrates an exemplary assembling procedure for battery module 20. First, shaft member 70 is held on jig base 100. A recessed member having a shape corresponding to the shape of the fastening member 71 provided at the lower end of sleeve 90 is formed on the upper surface of jig base 100. And a magnetic device (not shown in FIG. 10) for pulling in the metal sleeve 90 is arranged underneath jig base 100. When the magnetic device is operated and sleeve 90 is pulled in, shaft member 70 is securely stabilized on jig base 100.

[0038] Subsequently, cover 23 is inserted onto shaft member 70. At this time, the leading end member of lock member 72 undergoes elastic distortion toward the first position P1 (FIG. 9B) as it is being guided by the inner surface of through-hole 24. In this case, it is possible for through-hole 24 to pass through lock member 72. When through-hole 24 passes through lock member 72, lock member 72 opens based on its elasticity and returns to the second position P2 (FIG. 9A).

[0039] Furthermore, cell unit 40 is inserted onto shaft member 70. In this case also, the leading end member of the lock member 72 undergoes elastic distortion toward the first position P1 (FIG. 9B) as it is being guided by the inner surface of through-hole 45. In this case, it is possible for through-hole 45 to pass through lock member 72. When through-hole 45 passes through lock member 72, the lock member 72 opens based on its elasticity and returns to the second position P2 (FIG. 9A).

[0040] Furthermore, housing 22 is inserted to shaft member 70. In this case also, the leading end member of lock member 72 undergoes elastic distortion toward the first position P1 (FIG. 9B) as being guided by the inner surface of through-hole 24. In this case, it is possible for through-hole 24 to pass through lock member 72. When through-hole 24 passes through lock member 72, the lock member 72 opens based on its elasticity and returns to second position P2 (FIG. 9A). In this case, lock member 72 is locked to housing 22 and separation of cell unit 40 and each of housing 22 and cover 23 from the shaft member 70 can be prevented. Moreover, when separation of housing 22 is prevented, surface pressure is applied to cell unit 40. And as a result, power element of flat cell 30 can be adequately suppressed and retention of battery performance can be achieved.

[0041] Subsequently, edge member 23a of the cover 23 is rolled in at edge member 22a of housing 22 by a caulking device not shown in the figures so as to mutually seal cover 23 and housing 22.

[0042] When operation of the magnetic device is stopped and battery module 20 is removed from jig base 100, the assembly process of battery module 20 is completed.

[0043] FIG. 12 is a cross-section view that shows the main unit of a battery module 110 of a comparison example where sleeve 113 is inserted only into through-hole 112 of cell unit 111.

[0044] Upon assembling battery modules 111 of a comparison example, pins are inserted into the jig base 100 shown in FIG. 10, and cover 114, sleeve 113, cell unit 111, and housing 115 are sequentially inserted onto the pins in said order and caulking is provided. In this procedure, through-hole 116 undergoes deformation and the pin bites into them when cover 114 and housing 115 undergo deformation at the time of caulking, and removal of assembled battery module 110 from the assembling jig is difficult.

Furthermore, when sleeve 113 alone is inserted to the through-hole 112 of cell unit 111, shearing /d/ is likely to form between the center O1 of the through-hole 116 of each cover 114 and housing 115 and the center O2 of the sleeve 113 in an assembled battery module 110 and stability of the accurate positioning of cover 114, housing 115 and sleeve 113 is difficult.

[0045] On the other hand, in the present embodiment of the present invention, shaft member 70 doubles as a jig for insertion of cover 23, cell unit 40, and housing 22 sequentially from the side of lock member 72 toward the side of the fastening member 71 in said order at the time of assembly of battery module 20. Therefore, removal of battery module 20 from the assembly jig can be done easily after assembly even when deformation of housing 22 and cover 23 occur at the time of the caulking process.

Furthermore, in battery module 20 after assembly, shaft member 70 penetrates housing 22 and cover 23; thus, shearing is less likely to occur between the center of through-hole 24 and the center of the shaft member 70 and positioning accuracy of housing 22 and cover 23 can be easily stabilized.

[0046] Furthermore, battery assembly 11 is explained in detail below. In this case, FIG. 1, FIG. 2, and FIG. 4 are used as references. Battery assembly 11 is constructed with a plurality of groups of battery modules 25 where multiple battery modules 20 are stacked as interfitting members (recessed member 93 and projection member 82) of shaft member

70 are fitted together with support means 50 (that supports group of battery modules 25) as shaft member 70 where interfitting members are mutually fitted are held from both sides of the group of battery modules 25.

[0047] The shaft member 70 of the present embodiment has a hollow structure having center hole 70a and support means 50 includes fastening bolt 51 inserted into the center hole 70a of the shaft member 70.

[0048] A constructing procedure of battery assembly 11 is explained in detail below. It should be noted that the upper-most battery module 20 is referred to as battery module A, the center battery module 20 is referred to as battery module B, and the lower-most battery module 20 is referred to as battery module C to simplify the explanation.

[0049] First, battery module C, the lower-most module, is arranged on base member 55. Base member 55 contains through-holes 55a for insertion of fastening bolts 51 and projections 55b having a shape corresponding to the recessed member 93 of shaft member 70. The recessed member 93 of shaft member 70 is fitted to the projection 55b on base member 55. In this case, battery module C is arranged on base member 55 in a positioned state.

[0050] Subsequently, battery module B, the middle battery module, is arranged on battery module C. At this time, recessed member 93 of the shaft member 70 of battery module B is fitted to the projection member 82 of the shaft member 70 of battery module C. In this case, battery module B is arranged on battery module C in a positioned state.

[0051] Furthermore, battery module A, the upper-most battery module, is arranged on battery module B. At this time, recessed member 93 of the shaft member 70 of battery module A is fitted to the projection member 82 of the shaft member 70 of battery module B. In this case, battery module A is arranged on battery module B under positioned state.

[0052] When stacking of each battery module C, B, and A is achieved while fitting the interfitting members (recessed members 93 and projection members 82) of shaft member 70, production of a group of battery modules 25 where individual battery modules C, B, and A are mutually positioned can be easily achieved.

[0053] Furthermore, a top member 56 is arranged on battery module A. Top member 56 contains through-hole 56a for insertion of fastening bolt 51 and recessed member 56b having a shape corresponding to projection member 82 of shaft member 70. The recessed member 56b of top member 56 is fitted to the projection member 82 of shaft member 70 of battery module A. In this case, top member 56 is arranged on battery module A in a positioned state.

[0054] And furthermore, fastening bolt 51 is inserted into through-hole 55a of base member 55, center hole 70a of three shaft members 70 connected together, and through-hole 56a of top member 56 and fastening bolt 51 is secured with nut 52. In this manner, shaft member 70 mutually fitted at the interfitting member is held from both sides of the group of battery modules 25, and group of battery modules 25 is retained. Each group of battery modules 25 is fastened at four corners (FIG. 1). In the present embodiment, support means 50 that holds group of battery modules 25, is formed by base member 55, top member 56, and fastening bolt 51.

[0055] As shown in FIG. 2 and FIG. 4, a clearance CL of the space between battery modules 20 is regulated by shaft member 70 based on mutual fitting of the interfitting members. Clearance CL between battery modules 20 varies depending on the layout of the vehicle and the dimensions required for function of the cool air passages 61, but in general, it is several millimeters.

[0056] FIG. 13 is a cross-section view of the main area of battery assembly 120 of a comparison example assembled with battery module 110 shown in FIG. 12. When battery assembly 120 is made from battery modules 110 shown in FIG. 12, it is necessary to insert cylindrical collars 121 between the battery modules 110 for regulating clearance CL of the space between battery modules 110. However, the number of collars 121 is high and the work requires significant time. Furthermore, in battery module 110 of the comparison example, positioning accuracy of case 114 and case 115 and sleeve 113 is not stable as explained above, therefore, smooth insertion of the aforementioned collars 121 onto sleeves 113 cannot be achieved and is inconvenient.

[0057] On the other hand, in the present embodiment of the invention, the clearance between battery modules 20 is regulated by shaft member 70 where interfitting members are mutually fitted. The portion of shaft member 70 extending outside of housing 22 and cover 23 functions as a collar; thus, insertion of a collar, which is a separate component, between battery modules 20 is not required. Therefore, the attachment process of the collar is eliminated and assembling of battery assembly 11 can be simplified.

Furthermore, the number of parts is reduced and production of a cost-effective battery assembly 11 is made possible.

[0058] As explained above, according to the aforementioned embodiment, production of battery module 20 with simplified construction of a battery assembly is made possible and battery assembly 11, comprising multiple battery modules 20, can be constructed.

[0059] Modified Example of Shaft Member:

FIG. 11A and FIG. 11B are a vertical cross-section view and a top view of battery module 20 used for explanation of a modified example 74 of the shaft member. Lock member 72 is not limited to the structure of the aforementioned embodiment where the lock member is free to move between first position P1 and second position P2 based on elastic displacement as long as the structure is free to move between the first position P1 and the second position P2, and for example, lock member 72 may be free to move between the first position P1 and the second position P2 through rotation with the axis of the shaft member as the center of rotation. In specific terms, as shown in FIG. 11A and Fig. 11B, shaft member 74 comprising a metal sleeve 94 and a rib-shaped lock member 72 that extends from the outer surface of sleeve 94 outward surface is formed integrally. Notch member 24a through which lock member 72 can be inserted is provided for the through-hole 24 matching the phase of the aforementioned lock member 72. In the example shown in the FIG. 4, lock members 72 are provided at intervals of 90 degrees and 4 notch members 24a are provided at 90 degree intervals corresponding to the lock members. Similar notches are provided for the through-hole 45 of cell unit 40 as well. The position where the lock member 72 and notch member 24a match corresponds to the first position P1 and the position where the axis of the shaft member 74 is rotated 45 degrees with the axis of shaft member 74 as the center corresponds to the second position P2.

[0060] In assembling of the aforementioned battery module 20, after inserting housing 22 onto shaft member 74 and lock member 72 is rotated 45 degrees with the axis of shaft member 74 as the center, lock member 72 is locked to the housing 22 and separation of cell unit 40, housing 22, and cover 23 from the shaft member 74 can be prevented.

[0061] In the aforementioned examples, a case where shaft members 70 and 74 have a hollow structure is shown, but the present invention is not limited to the aforementioned examples. Upon assembly of battery module 20, shaft member doubles as a jig for insertion of each housing 22, cover 23, and cell unit 40, and it is not necessary to have a hollow structure. Furthermore, it is not necessary for the shaft member to have a hollow structure upon constructing battery assembly 11 as long as connection is made possible by fitting of interfitting members. Therefore, the shaft member may be a solid material. In this case, the support means 50 used has a structure where base member 55 and top member 56 are fastened by a fastening bolt provided at a different position from that of

the shaft member. The shaft member with interfitting member mutually fitted is held from both sides of the group of battery modules 25 with the fastened base member 55 and top member 56, and battery modules 25 are supported.

[0062] In the above-mentioned examples, lock member 72 alone has a structure that is free to move, but the lock member may be a structure that is free to move between the first position P1 and the second position P2 in the present invention, but a structure that is free to move may be provided between the first position P1 and the second position P2 with a fastening member as well. In this case, insertion of housing 22 and cover 23 onto the shaft member inserted onto cell unit 40 ahead of time is made possible simultaneously from both ends.

[0063] According to the invention described above, the shaft member doubles as a jig at the time of assembling of the battery module; thus, removal of the battery module after assembly from the assembling jig can be done easily even when the case undergoes deformation. Furthermore, the shaft member extends beyond the case after assembly of the aforementioned battery module; thus, shearing is less likely to occur between the center of the through-hole and the center of the shaft member and positional accuracy of the case and the shaft can be easily stabilized. Furthermore, formation of a battery module arrangement where battery modules are mutually positioned can be easily achieved as many battery modules are stacked while interfitting members of the shaft member are fitted together. Moreover, when stacking is done while the interfitting members of the shaft member are fitted together, a gap is formed between battery modules; thus, provision of a separate component to form the aforementioned gap, for example, insertion of a collar between battery modules is not required. Therefore, the collar attachment process can be eliminated and construction of battery assembly can be simplified. Furthermore, the number of components can be reduced, thus, a cost effective battery assembly can be produced.

[0064] Various embodiments of the invention have been described. These and other embodiments are within the scope of the following claims.

CLAIMS:

1. A battery module, which forms an item unit for construction of a battery assembly, comprising:
 - a cell unit having a plurality of cells;
 - a housing and a cover to store the cell unit; and
 - a shaft member inserted into a through-hole provided in the cell unit and a through-hole provided in the housing and a through-hole provided in the cover, wherein the shaft member comprises a length that allows protrusion from each of the housing and the cover.
2. The battery module of claim 1, further comprising a lock to lock the shaft member to the housing or to the cover.
3. The battery module of claim 2, wherein the lock comprises a fastening member provided at an area where the shaft member protrudes from the cover, wherein the fastening member is fastened to the cover.
4. The battery module of claim 2, wherein the lock comprises a lock member provided at an area where the shaft member protrudes from the housing, wherein the lock member is locked to the housing.
5. The battery module of claim 4, wherein the lock member has a structure that is free to move between a first position where insertion into the through-hole of the cell unit and into the through-holes of the housing and the cover is allowed and a second position where separation of the cell units and the housing and the cover from the shaft member is prevented.
6. The battery module of claim 4, wherein the shaft member doubles as a jig for insertion of the cover, the cell unit, and the housing in said order from the lock member side toward the fastening member at the time of assembly of the battery module.

7. The battery module of claim 4, wherein the lock member is free to move between a first position and a second position as the lock member undergoes elastic displacement in the direction of an axis of the shaft member.

8. The battery module of claim 4, wherein the lock member is free to move between the first position and second position as the lock member undergoes rotation with an axis of the shaft member as the center.

9. The battery module of claim 1, wherein the cover and the housing are mutually locked as an edge member of the housing forms a seam with an edge member of the cover.

10. The battery module of claim 1,
 wherein the shaft member is a first shaft member of a first module, further comprising an interfitting member formed on both end faces of the first shaft member in the axis direction; and
 wherein the axis of the first shaft member and an axis of a second shaft member of a second battery module are matched at the time of connecting the second shaft member along the axis direction as the first shaft member is fitted at an interfitting member of the second shaft member.

11. The battery module of claim 10,
 wherein the battery module is formed into a battery module arrangement comprising a plurality of battery modules by stacking the battery modules where the interfitting members of the shaft members are locked; and
 wherein a support structure supports the battery modules from both sides of the battery module arrangement when the shaft members with locked interfitting members are locked, thereby forming the battery assembly.

12. The battery module of claim 11, wherein the shaft member regulates a gap between the battery module and a second battery module when the interfitting members are in a fitted state.

13. The battery module of claim 11, wherein the shaft members are hollow and wherein a center hole is the through-hole and the support structure includes a fastening bolt.

14. A battery assembly comprising:

a plurality of battery modules wherein an axis of a first shaft member of a first battery module and an axis of a second shaft member of a second battery module are matched at the time of connecting the second shaft member along the axis direction as the first shaft member is fitted at an interfitting member of the second shaft member, and wherein the plurality of battery modules are stacked where each battery module's interfitting member of a shaft member are locked; and

a support structure that supports the battery modules from both sides of the plurality of battery modules when each of the battery module's interfitting members are locked.

15. The battery system of claim 14, wherein the shaft members regulate a gap between each of the battery modules when the interfitting members are in a fitted state.

16. The battery system of claim 14, wherein the shaft members are hollow and wherein a center hole is a through-hole and the support structure includes a fastening bolt.

17. The system of claim 14, wherein each of the battery modules comprises:

a cell unit having a plurality of cells;

a housing and a cover for storing the cell unit;

a shaft member inserted into a through-hole provided in the cell unit and a through-hole provided in the cover and a through-hole provided in the housing, wherein the shaft member comprises a length that allows protrusion from each of the cover and the housing;

a fastening member, provided at an area where the shaft member protrudes from the cover, wherein the fastening member is fastened to the cover; and

a lock member, provided at an area where the shaft member protrudes from the housing, wherein the lock member is locked to the housing, and wherein the lock member has a structure that is free to move between a first position where insertion into the through-hole of the cell unit and into the through-holes of each of the cover and of the housing is allowed and a second position where separation of the cell units, the cover, and the housing from the shaft member is prevented, and wherein the shaft member doubles as a jig for insertion of the cover, the cell unit, and the housing in said order from the lock member side toward the fastening member at the time of assembly of the battery module.

18. A method of manufacturing a battery module comprising:

storing a cell unit, which contains a plurality of battery cells, within a housing having a cover to form a storage space;

inserting a shaft member into a through-hole provided in the cell unit and a through-hole provided in the cover and a through-hole provided in the housing, wherein the shaft member comprises a length that allows protrusion from each of the cover and the housing;

fastening a fastening member to the cover at an area where the shaft member protrudes from the cover;

locking a locking member to the housing at an area where the shaft member protrudes from the housing, such that the lock member is free to move between a first position where insertion into the through-hole of the cell unit and the through-holes of each of the cover and housing is allowed and a second position where separation of the cell units and each of the cover and housing from the shaft member is prevented; and

inserting the cover, the cell unit, and the housing in said order onto the shaft member from the lock member side toward the fastening member, wherein the shaft member doubles as a jig.

19. The method of claim 18, further comprising mutually locking the cover to the housing wherein an edge member of the housing forms a seam with an edge member of the cover.

20. A method of manufacturing a battery assembly comprising:
- matching an axis of a first shaft member of a first battery module and an axis of a second shaft member of a second battery module at the time of connecting the second shaft member along the axis direction as the first shaft member is fitted at an interfitting member of the second shaft member;
 - stacking a plurality of battery modules where each battery module's interfitting member of the shaft member are locked; and
 - inserting the plurality of battery modules into a support structure that supports the battery modules from both sides of the plurality of battery modules when each of the battery module's interfitting members are locked.
21. The method of claim 20, further comprising regulating a gap between the battery modules with the shaft members when the interfitting members are in a fitted state.
22. The method of claim 20, further comprising fastening a fastening bolt to the shaft member.
23. A battery module, which forms an item unit for construction of a battery assembly, comprising:
- means for enclosing a plurality of cells;
 - a shaft member inserted into a through-hole provided in the cell unit and a through-hole provided in the enclosing means, wherein the shaft member comprises a length that allows protrusion from the enclosing means; and
 - means for locking the shaft member to the housing or to the cover.

BATTERY MODULE AND BATTERY ASSEMBLY

ABSTRACT

The invention provides a battery module, which forms an item unit for construction of a battery assembly, comprising a cell unit having a plurality of cells, and a housing and a cover to store the cell unit. The battery module further comprises a shaft member inserted into a through-hole provided in the cell unit and a through-hole provided in the housing and a through-hole provided in the cover, wherein the shaft member comprises a length that allows protrusion from each of the housing and the cover. Furthermore, during construction of the battery module, the shaft member doubles as a jig for insertion of the cover, the cell unit, and the housing in said order for each of the modules within the battery assembly

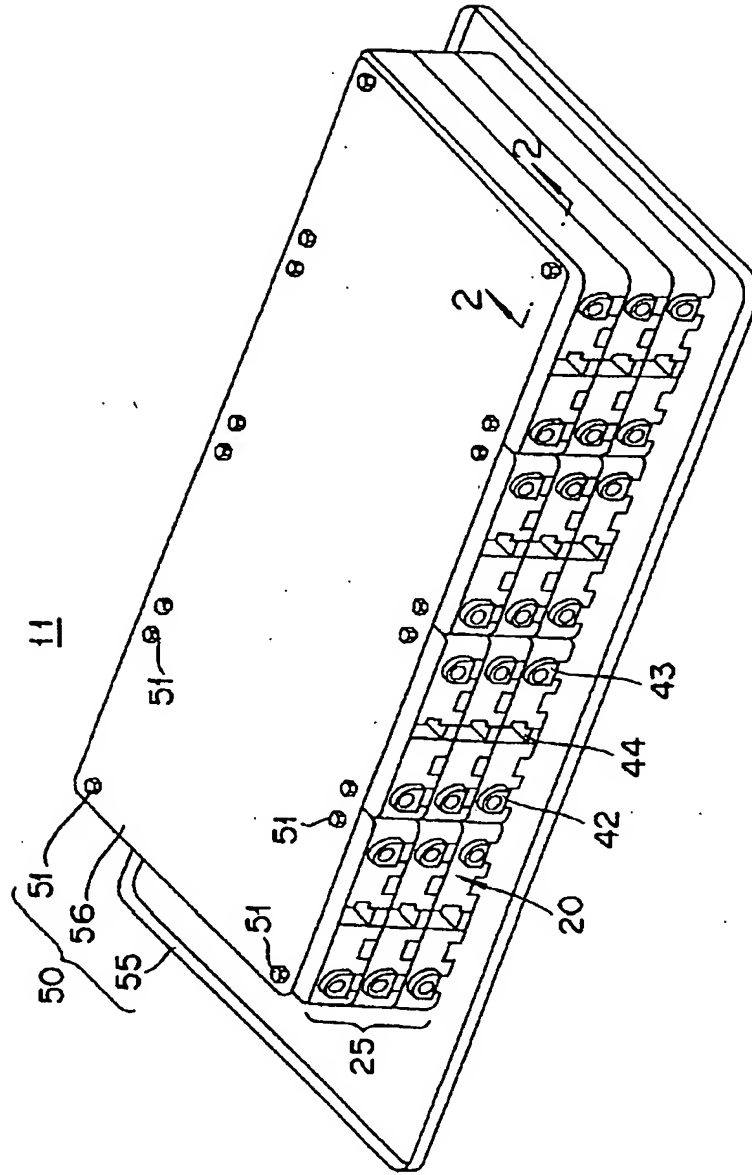


FIG. 1

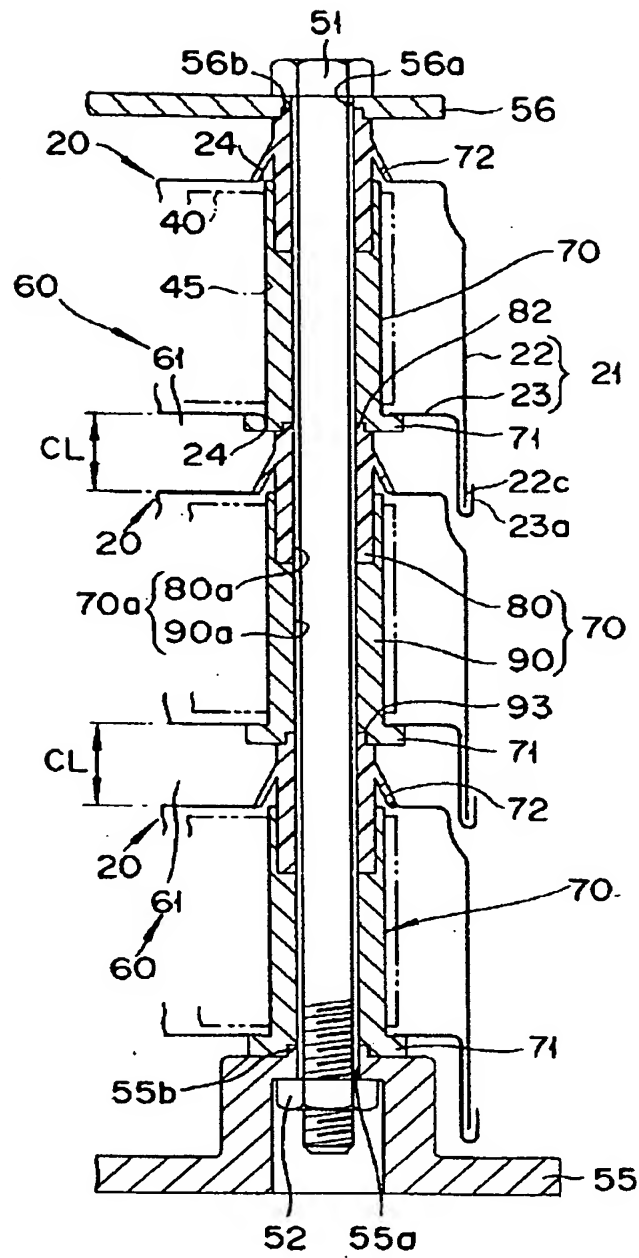


FIG. 2

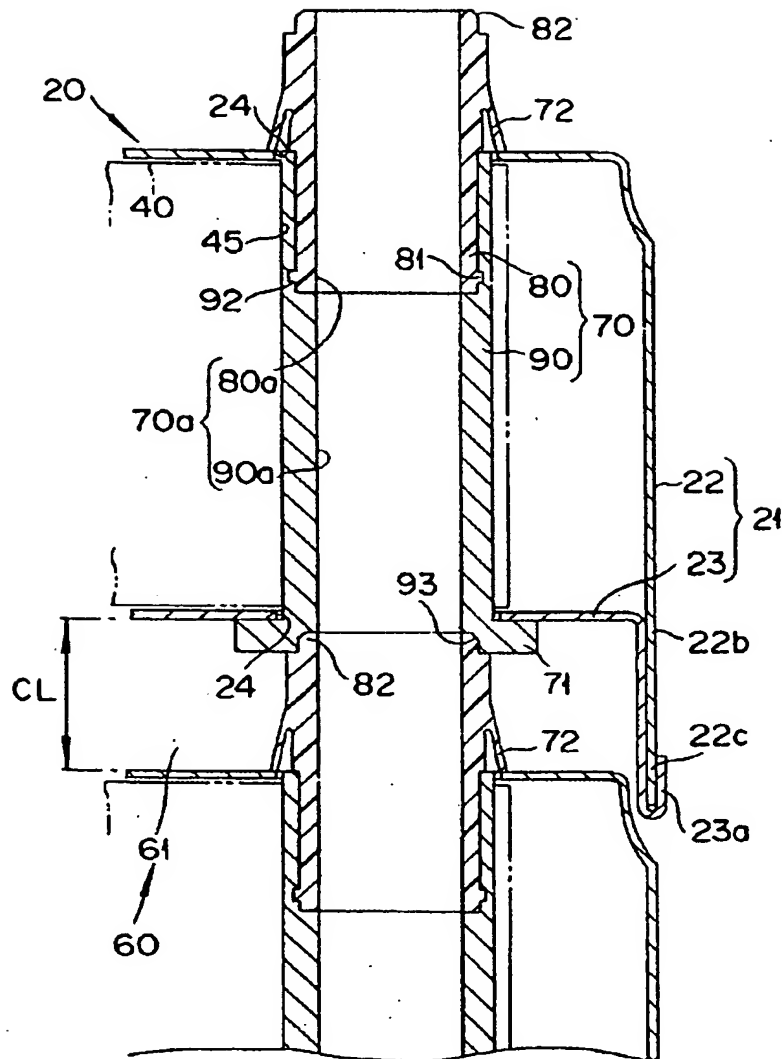


FIG. 4

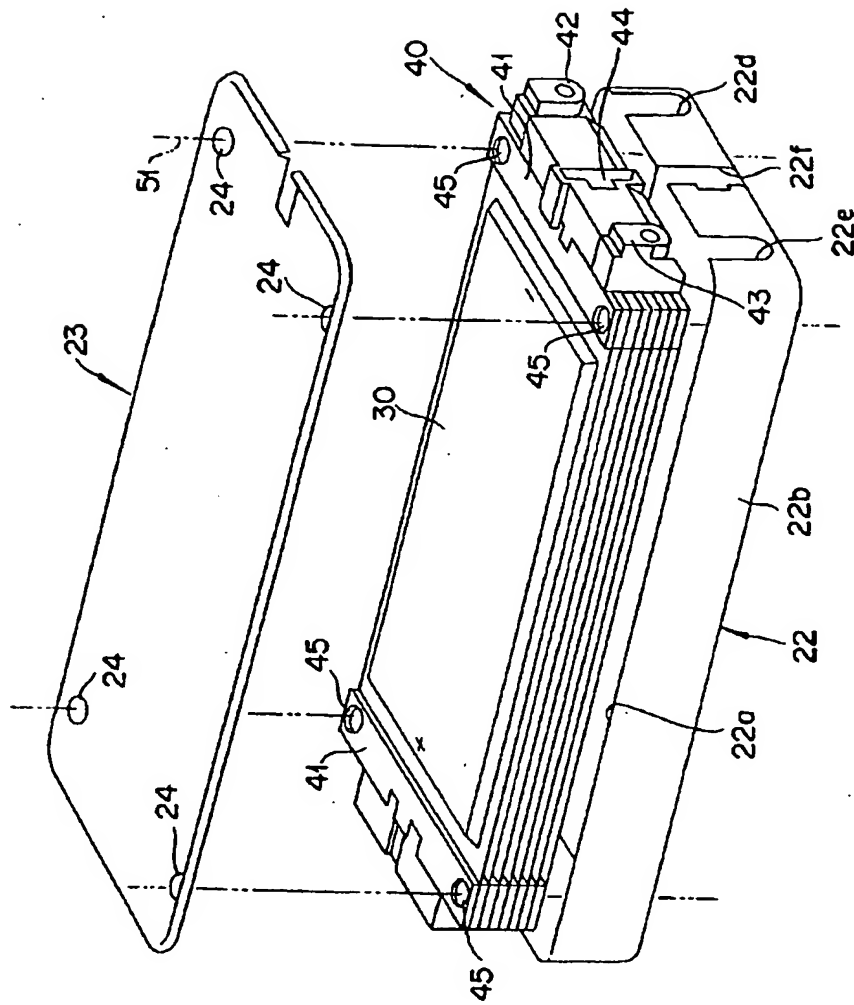


FIG. 5

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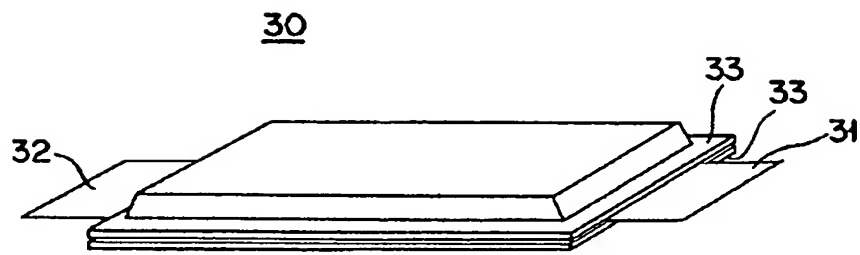


FIG. 6

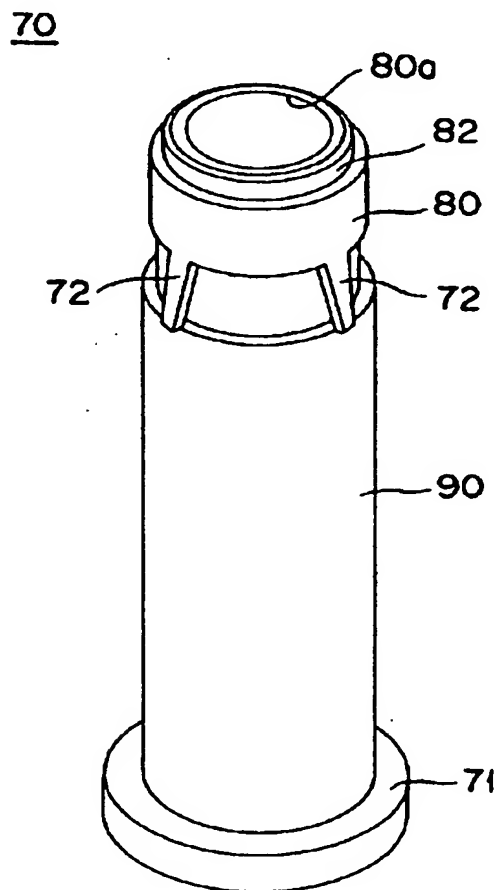


FIG. 7

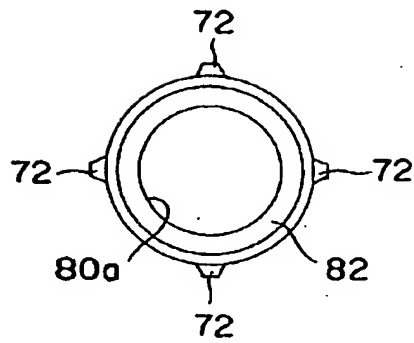


FIG. 8B

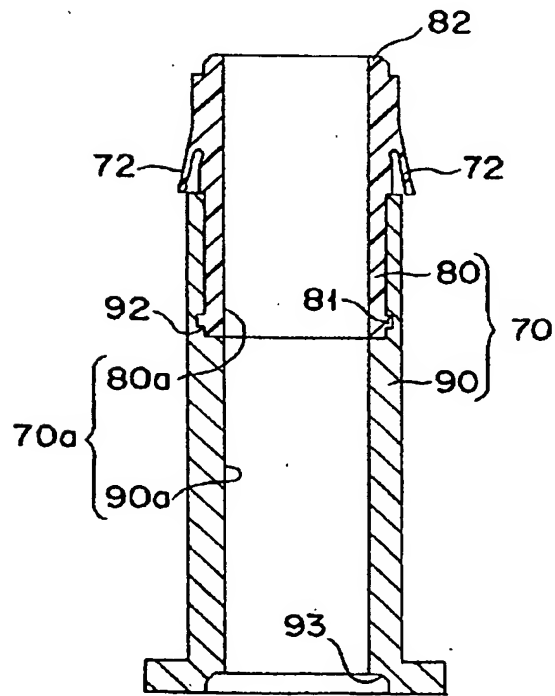


FIG. 8A

FIG. 9B

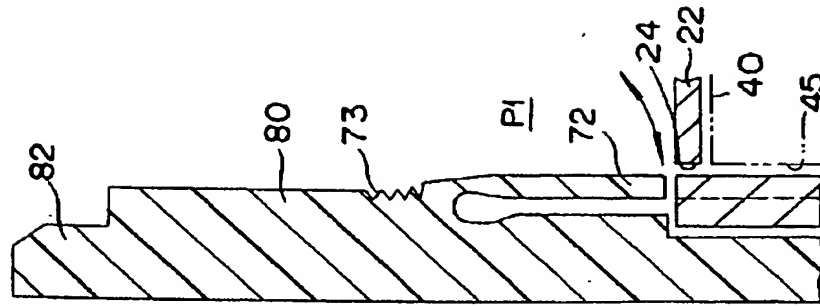
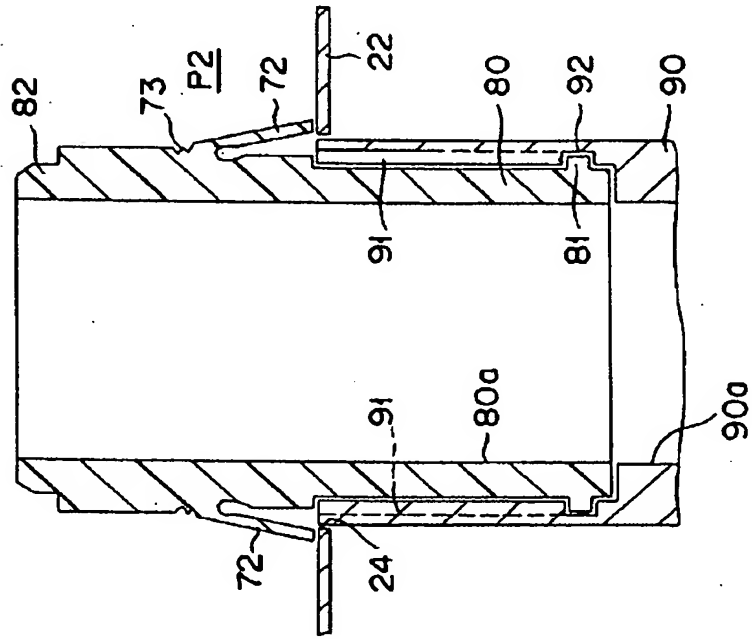


FIG. 9A



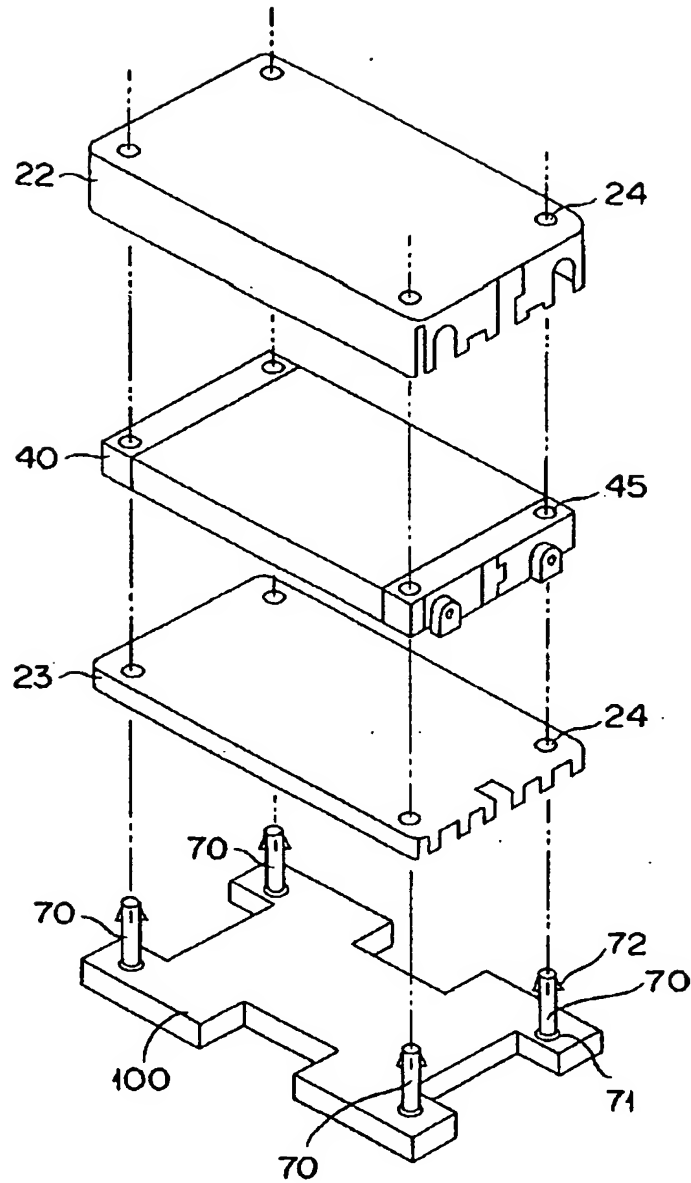


FIG. 10

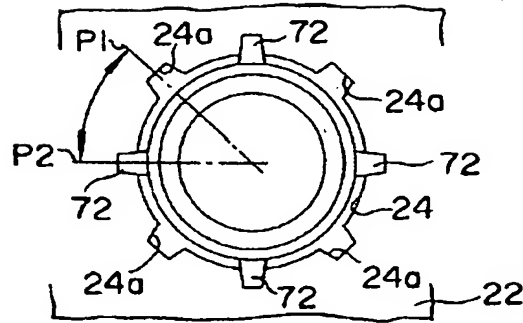


FIG. 11B

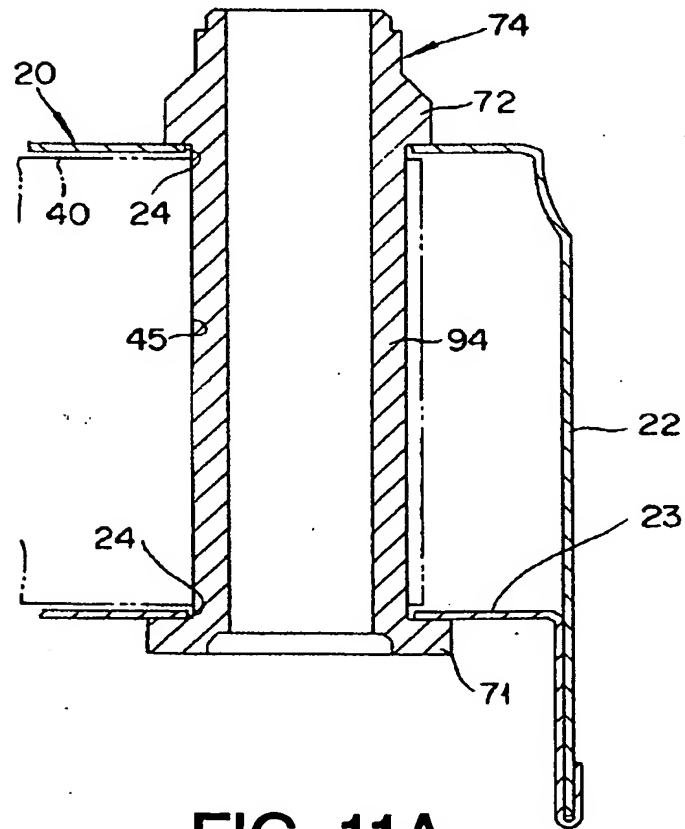


FIG. 11A

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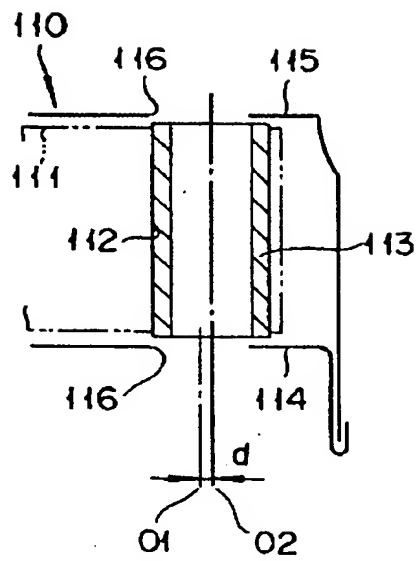


FIG.12

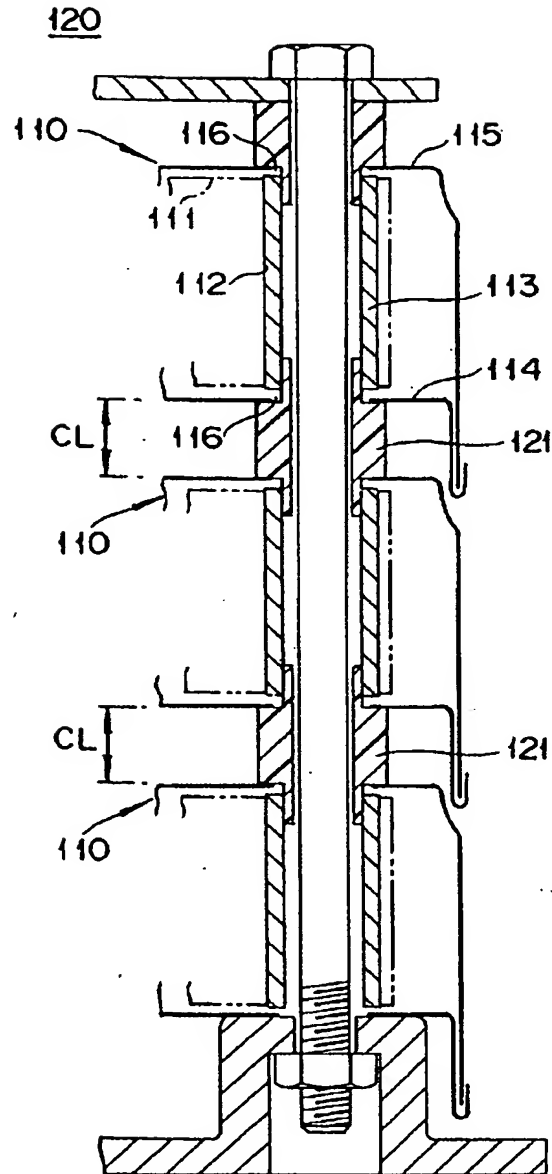


FIG. 13